

# A Global Modeling Initiative (GMI) Study: *The long-range, cross-tropopause transport of CO*

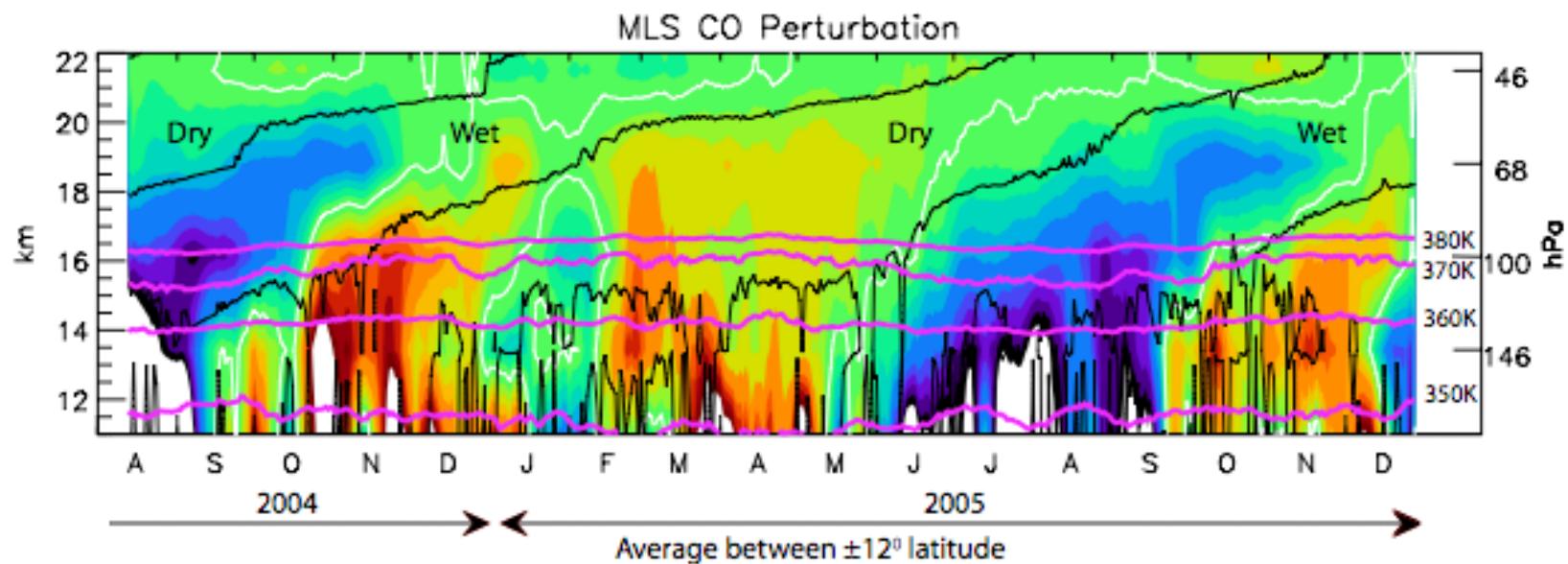
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*NASA Goddard Space Flight Center*

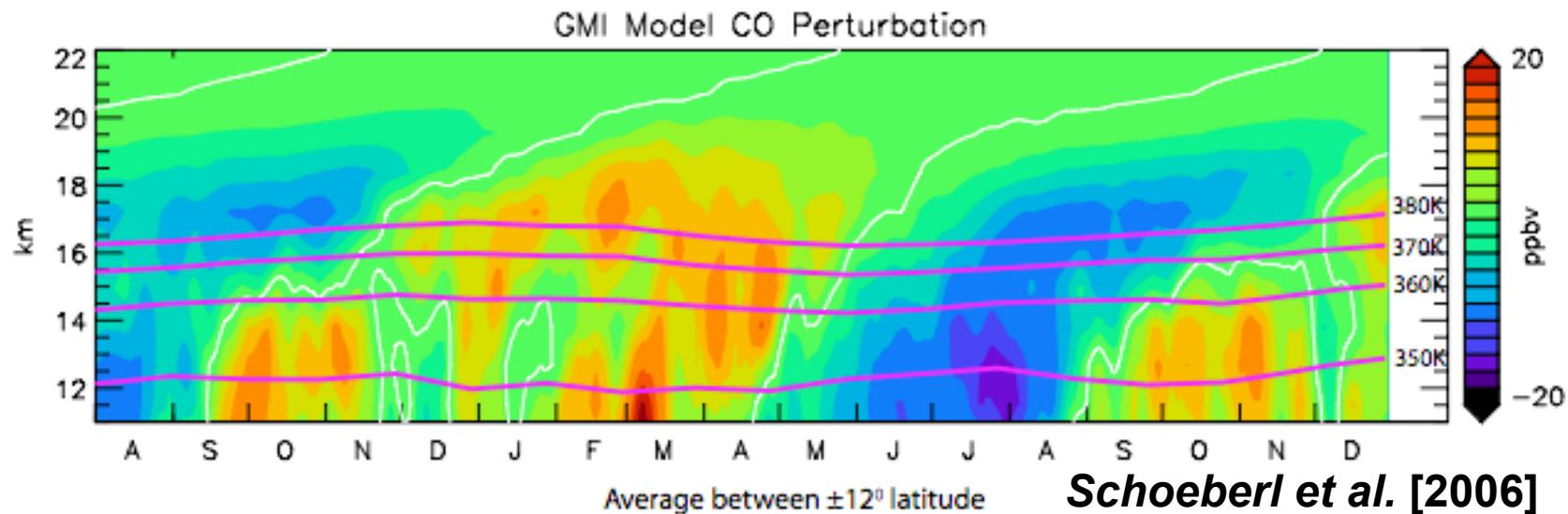
*\*Goddard Earth Science & Technology (GEST) Center, UMBC*

Nathaniel Livesey + MLS CO Team  
*Jet Propulsion Laboratory*

# Inspiration $\Rightarrow$ CO “Tape Recorder” in Aura MLS



Driven by Seasonal Biomass Burning and Convection.



Schoeberl et al. [2006]

# More on Tape Recorders

*Don't miss Mark Schoeberl's poster!*

“The Tropical Tape Recorders of Aura’s MLS”

## **But, why should anyone care?**

Biomass burning isn't a source of key players in the stratosphere, right?

**Because the pollutants may impact:**

- Lifetimes of Trace Gases in Tropical Tropopause Layer (TTL)\*  
CO, NMHC, etc. + OH

\*Air in TTL resides several weeks before crossing the tropopause.

- Radiation Budget – Dynamics in TTL  
ozone and aerosols - troposphere-to-stratosphere (TST) exchange

# GMI Combined Stratosphere-Troposphere (COMBO) Model

*Don't miss Anne Douglass' poster!*

“The Global Modeling Initiative “Combo” CTM -  
Applications to Analysis of Aura Data”

# Model Comparison to MOZAIC Aircraft Data in Upper Troposphere

Cruise Altitude: 9-12 km

## Japan Airlines Data

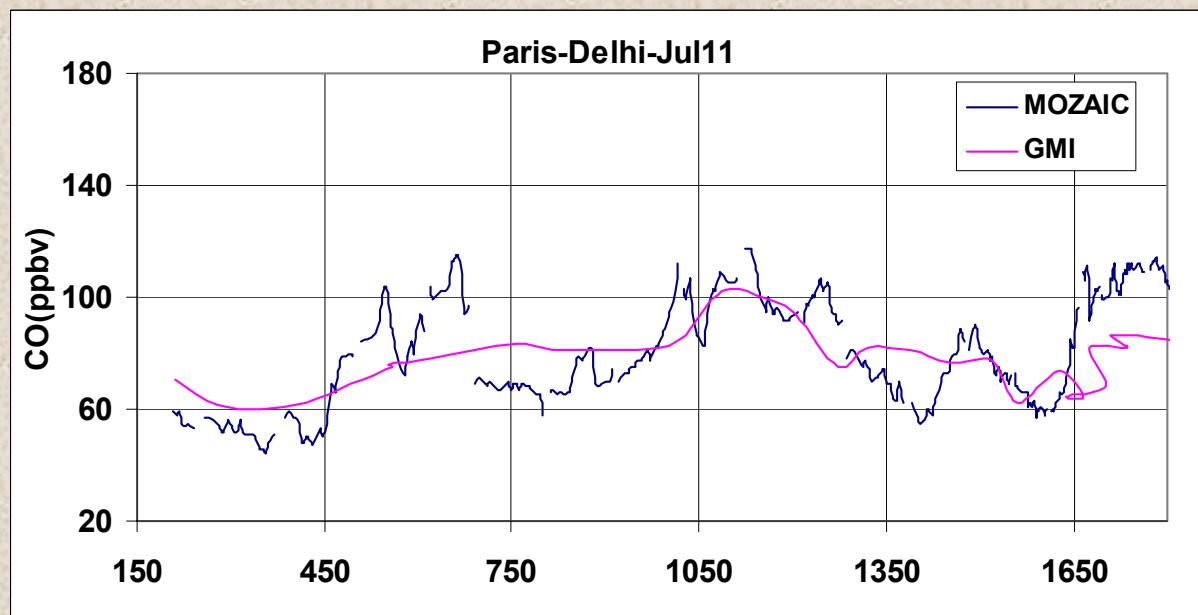
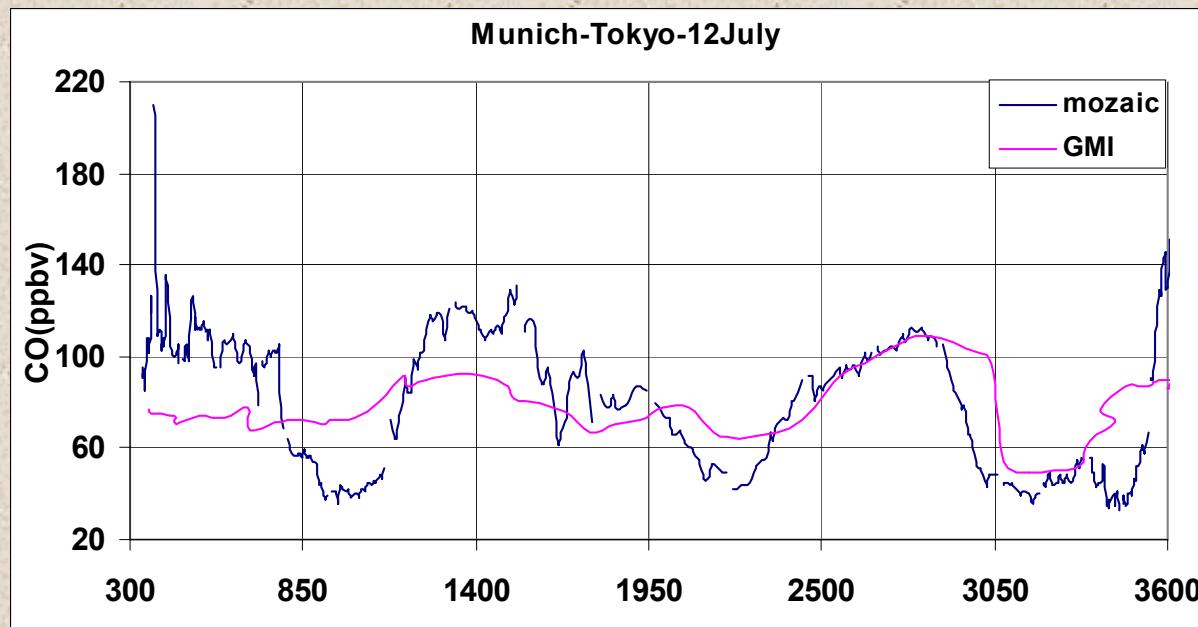
W. Pacific 40-130 ppbv  
1997 Indonesia <400 ppbv

Matsueda et al. [1998,1999]

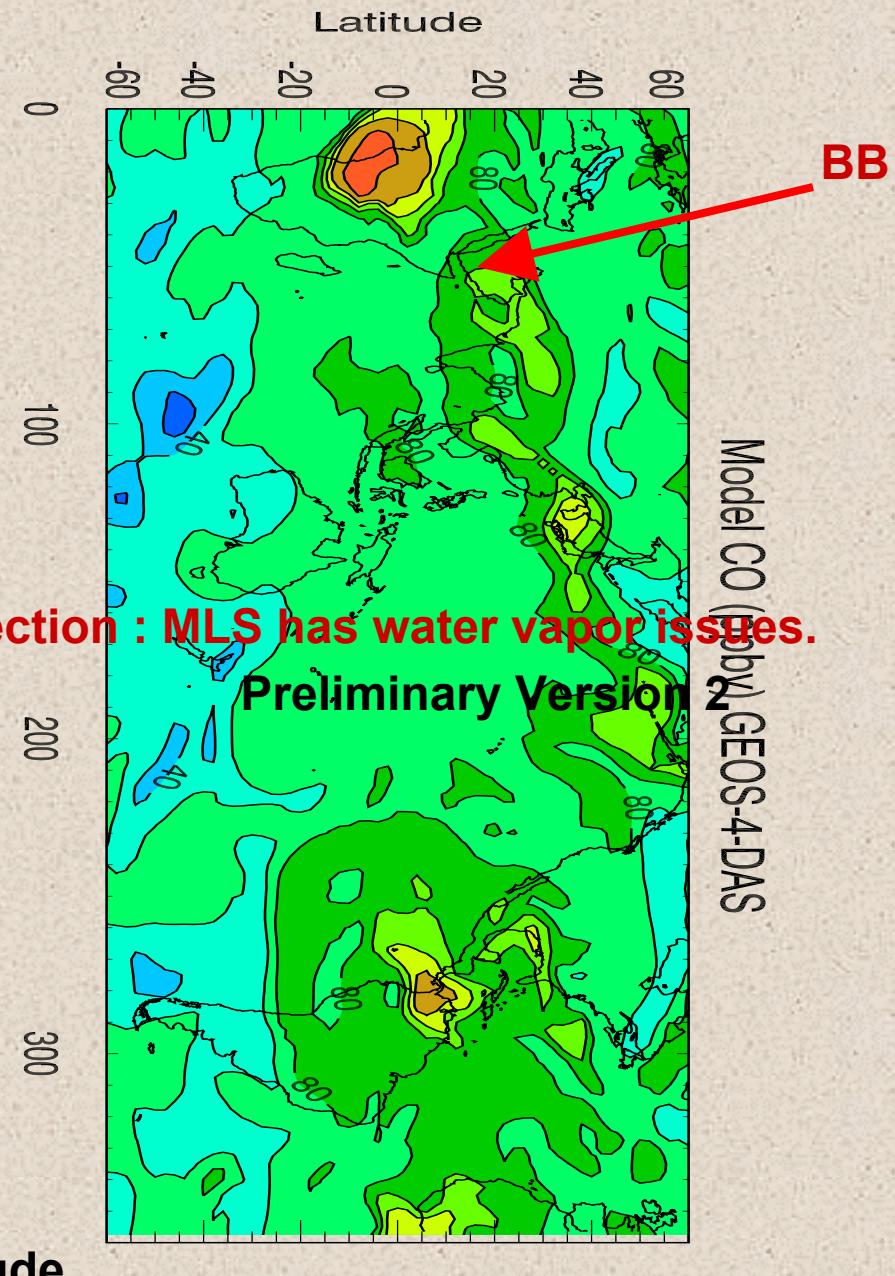
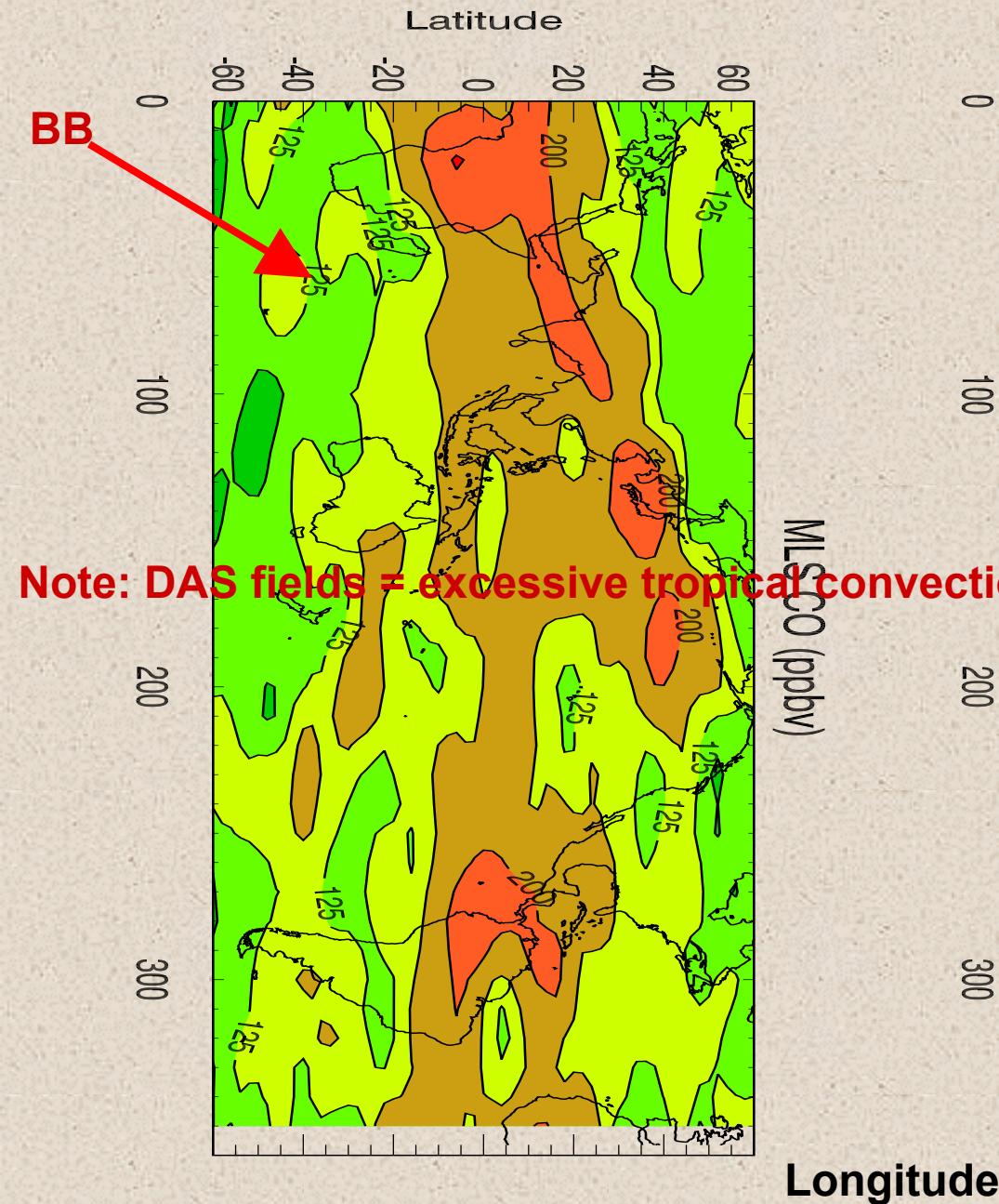
## MOZAIC Aircraft Data

Europe 50-140 ppbv  
Asia <150 ppbv  
Boreal BB >500 ppbv

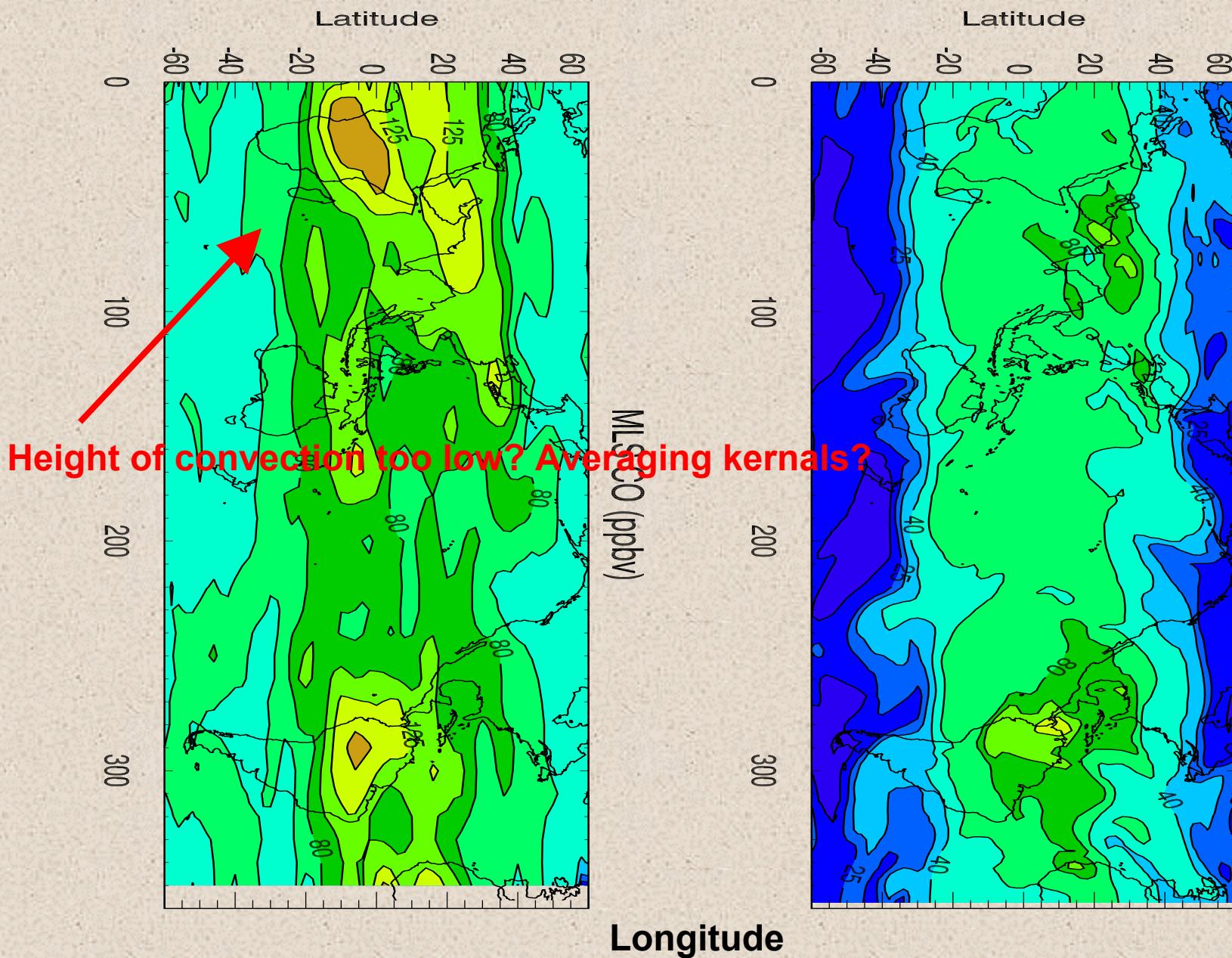
Nedelec et al. [2005]



# 215 hPa : September 21, 2005



# **146 hPa : September 21, 2005**



⇒ **Summary of MLS CO vs GMI CO Comparison**

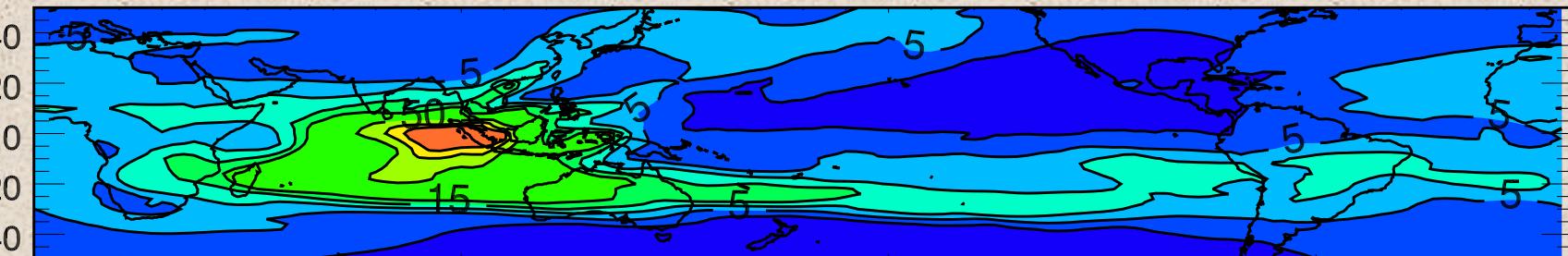
- *Spatial distributions of MLS CO similar to model, though biased high.*
- *But only few days of data so far.*
- *Both model and observational limitations.*

⇒ **Application of MLS CO Data in UT/LS**

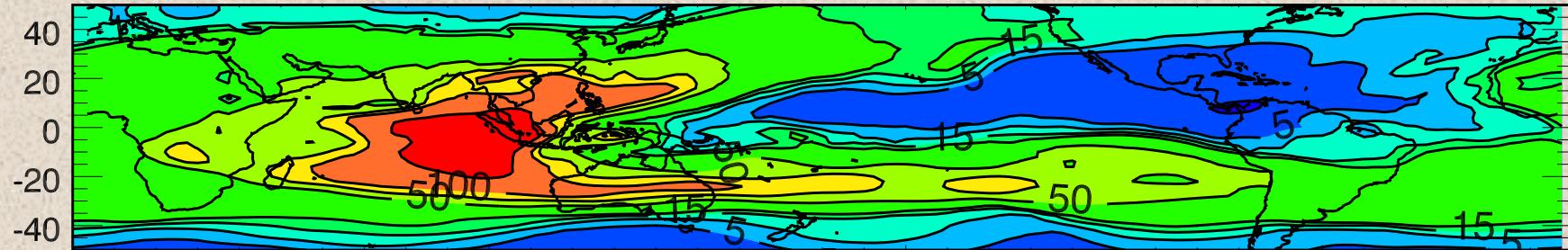
- *Transport of BB pollution to/in UT/LS*
- *BB causes much of the variation in CO in UT/LS*

# Indonesian Fires 1997: CO Perturbation (%) ~200 mb

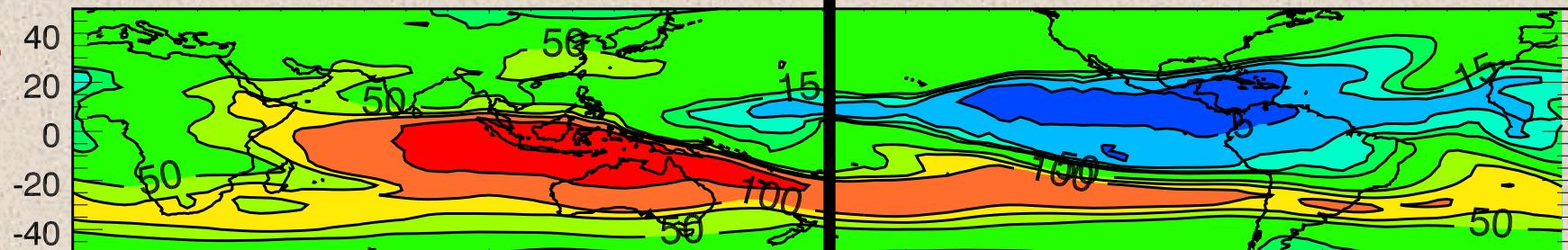
AUG



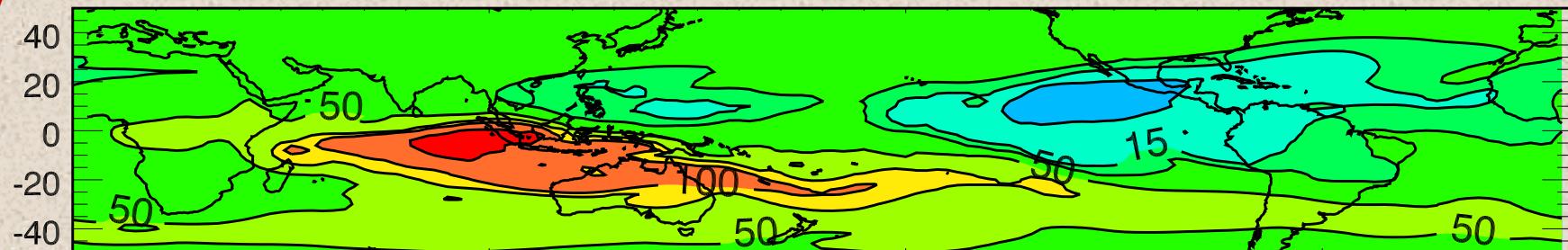
SEP



OCT



NOV



0

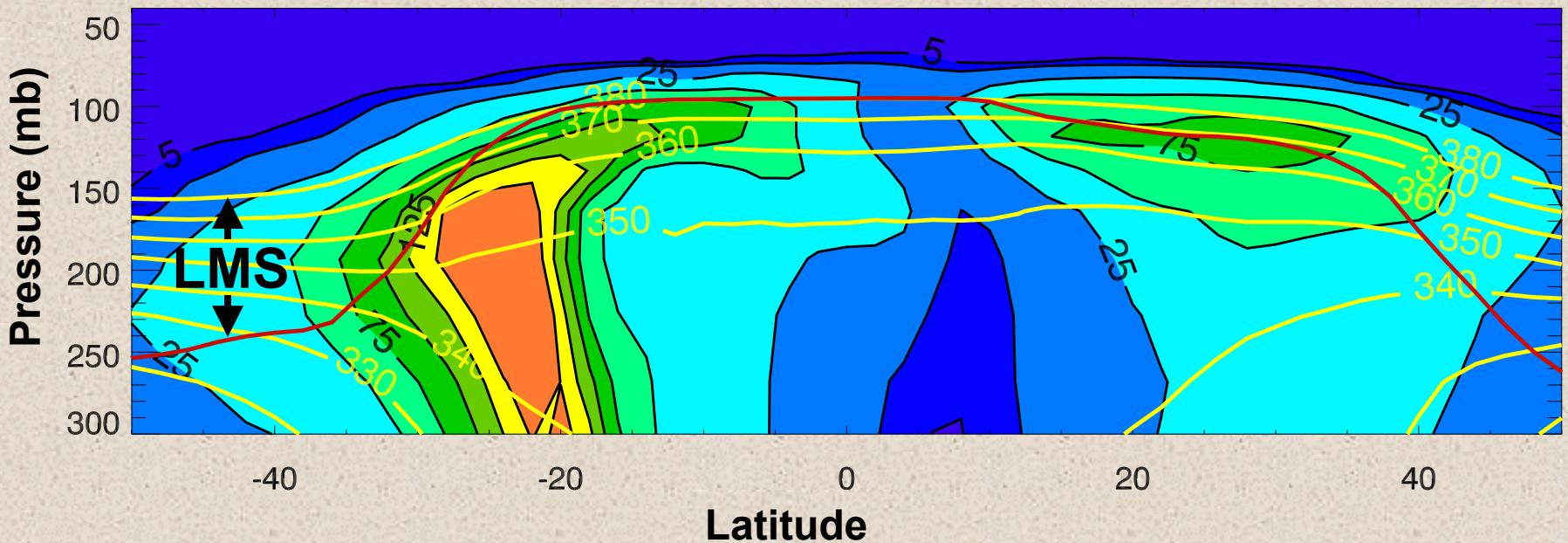
100

200

300

Longitude

# October 1997 : CO Perturbation (%) 180° Longitude



Yellow Lines = Isentropes

Red Line = Approximate Tropopause

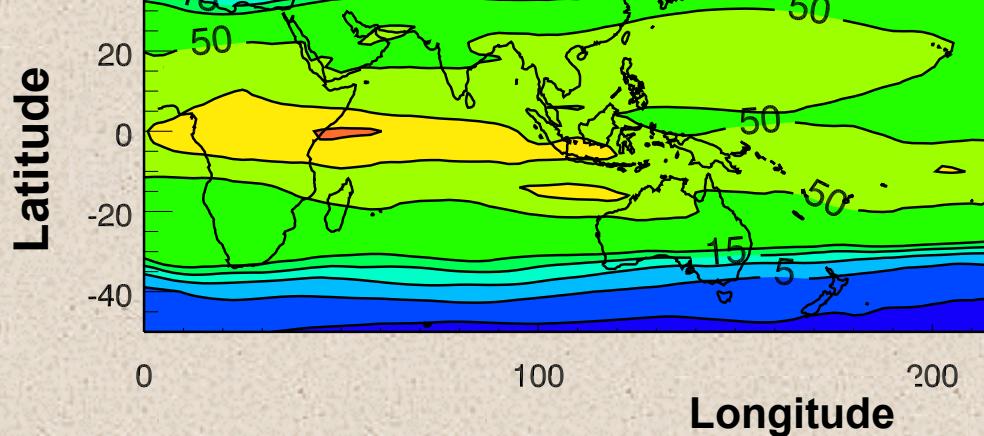
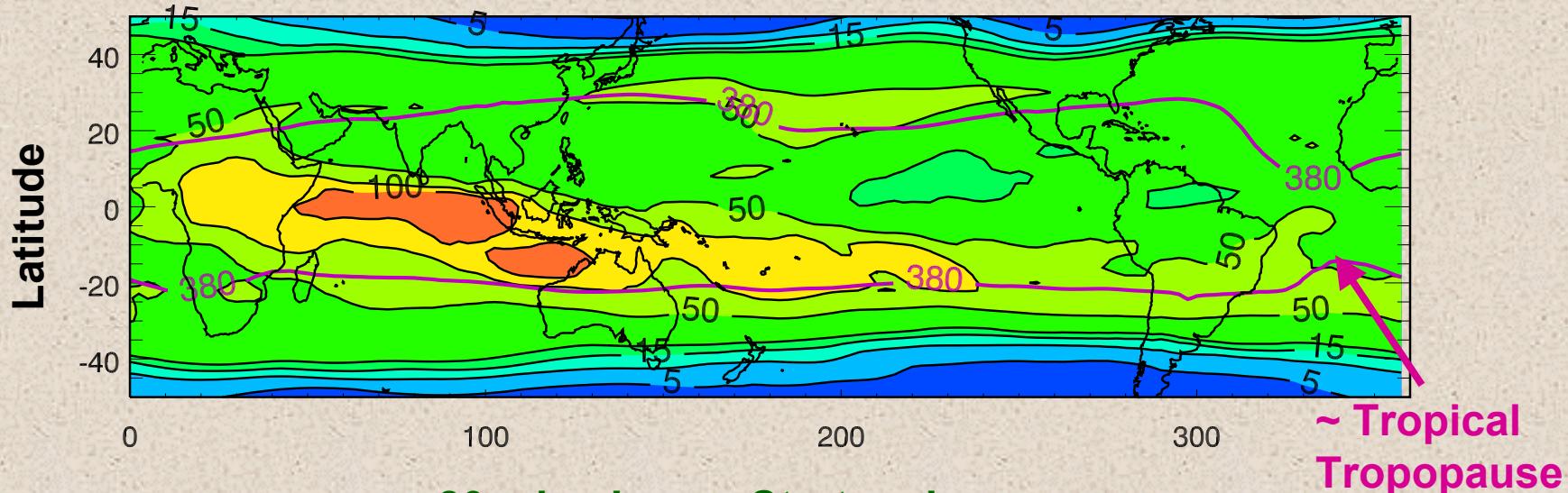
⇒ Troposphere-to-Stratosphere Exchange (TST) via Quasi-horizontal,  
Quasi-isentropic Exchange

⇒ But, pollution in Lowermost Stratosphere (LMS) returns to  
troposphere eventually

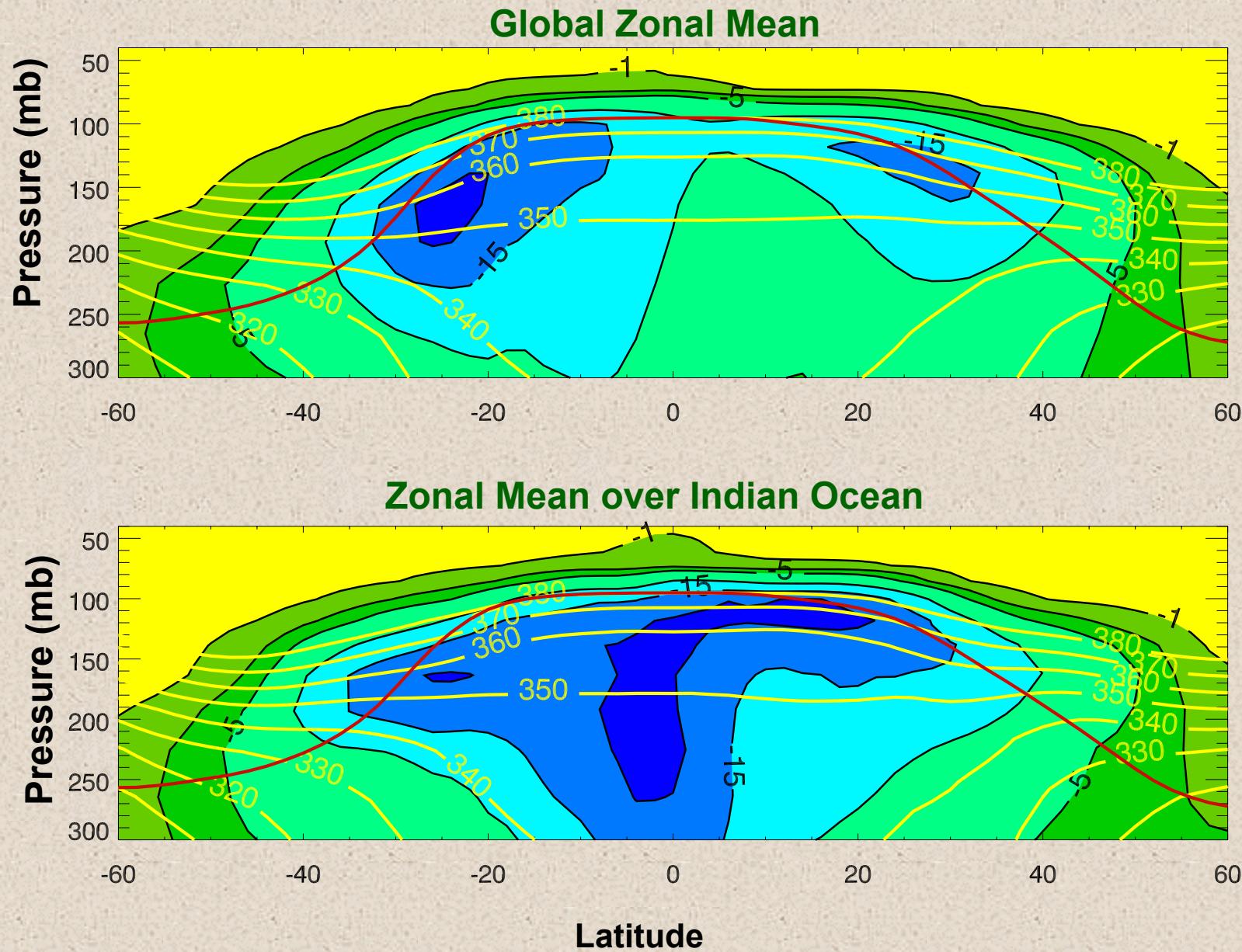
# November 1997: CO Perturbation (%)

⇒ TST via Slow Ascent in TTL

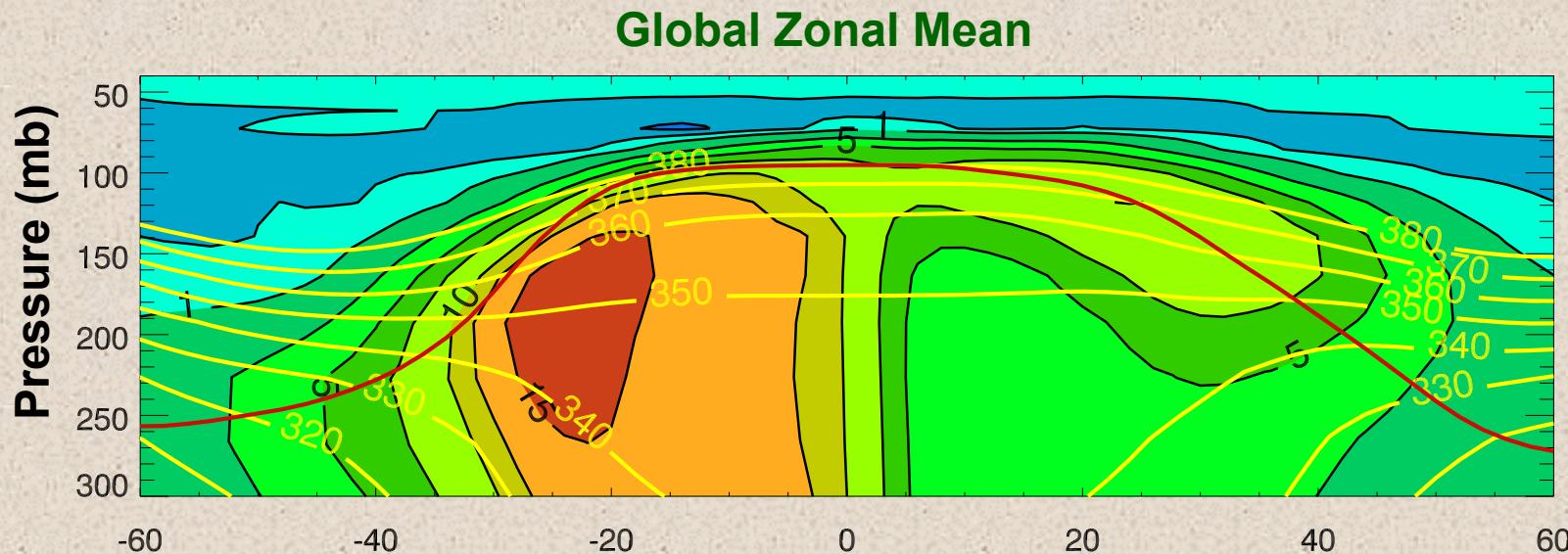
~100 mb – Near Tropical Tropopause



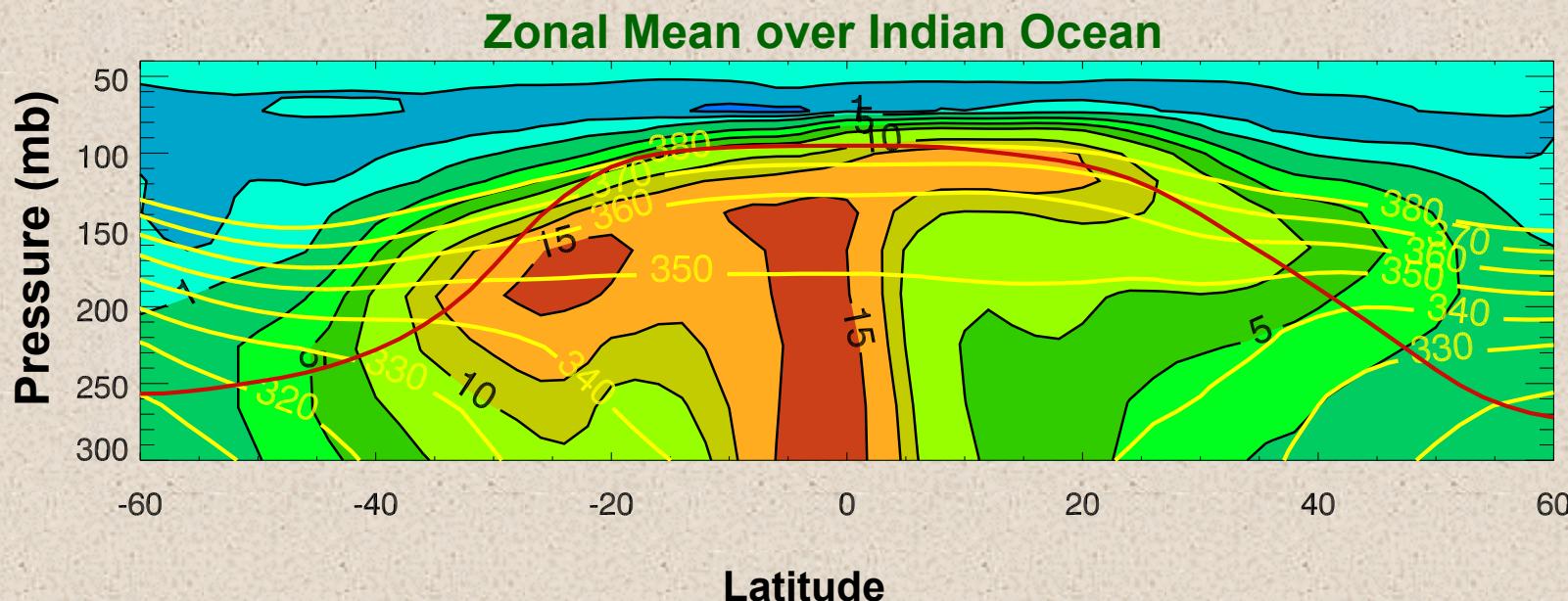
# October 1997: OH Perturbation (%)



# October 1997: Ozone Perturbation (ppbv)



**Locally: 25-100% increase over Maritime Continent!**



# Conclusions

- **CO Comparison: MLS & GMI Combo**

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- ⇒ Very encouraging.
- ⇒ Can we see evidence of biomass burning transport in UT?
  - Only a few days of data.
  - Vertical resolution adequate?

- **Big tropical burning event:**

- **Big tropical burning event:**
- ⇒ TST of pollution via:
  - slow ascent in TTL.
  - exchange in subtropical jets.

- ⇒ Impact on trace gases in TTL substantial.
  - Did pollution impact dynamics of TTL?  
Aerosols: shortwave radiative forcing at surface = -10 W/m<sup>2</sup> over Indian Ocean and -150 W/m<sup>2</sup> over Indonesia!
- ⇒ Driven by El Niño-induced drought & human activities.  
∴ 1997 scenario likely to repeat in future.

## Tropospheric & Stratospheric Chemistry

[Bey et al., 2001; Kinnison et al., 2001; Douglass et al., 2004; Considine et al., 2000]

## SMVGear Chemical solver

[Jacobson, 1995]

## Photolysis

Fast-JX [Wild et al., 2000; Bian and Prather, 2002]

## Transport algorithms: Advection, Convection, Boundary Layer Mixing

[Rasch et al., 1997; Lin & Rood, 1996]

eddy-diffusion, K coefficients from meteorological fields

## Dry & Wet Deposition

[Wang et al., 1998; Wesley et al., 1985; Liu et al., 2000]

## Global Modeling Initiative's (GMI) Combined Stratosphere-Troposphere (COMBO) CTM

## Aerosol Fields **GOCART**

[Chin et al., 2002;  
Ginoux et al., 2002;  
Martin et al., 2003]

## Meteorological Fields [NASA-GMAO]

- . 42 layers in hybrid coordinates
- . Surf-0.01 hPa
- . 2°x2.5° horizontal resolution

GEOS-4-DAS : 2004-5

GEOS-4-AGCM : 1994-8 SSTs

## Emission Inventories

fossil fuels, biomass burning, biofuels

[Duncan et al., 2006; Duncan et al., 2003;  
Yevich et al., 2003]

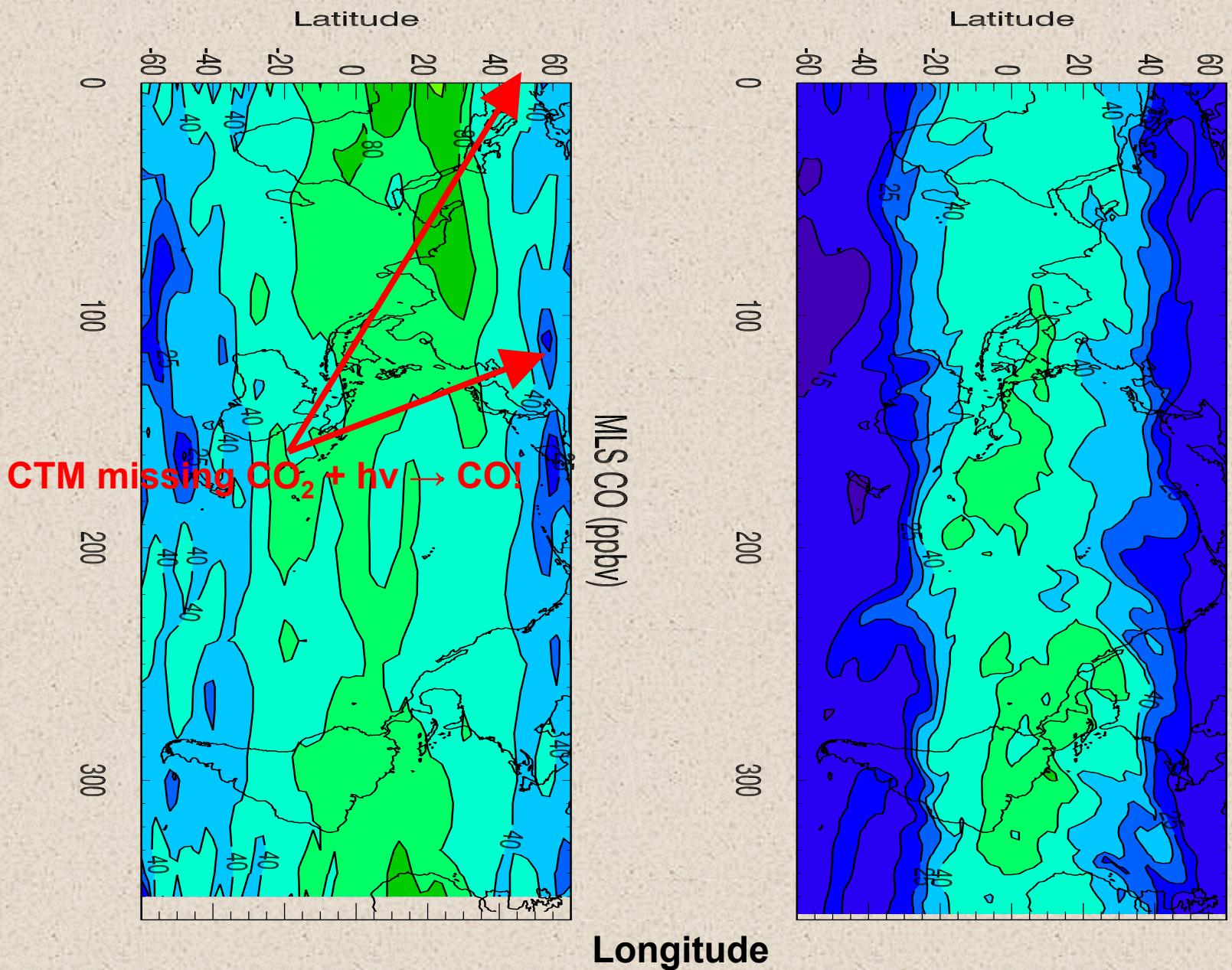
Algorithms for biogenic emissions

[Guenther et al., 1995; Wang et al., 1998]

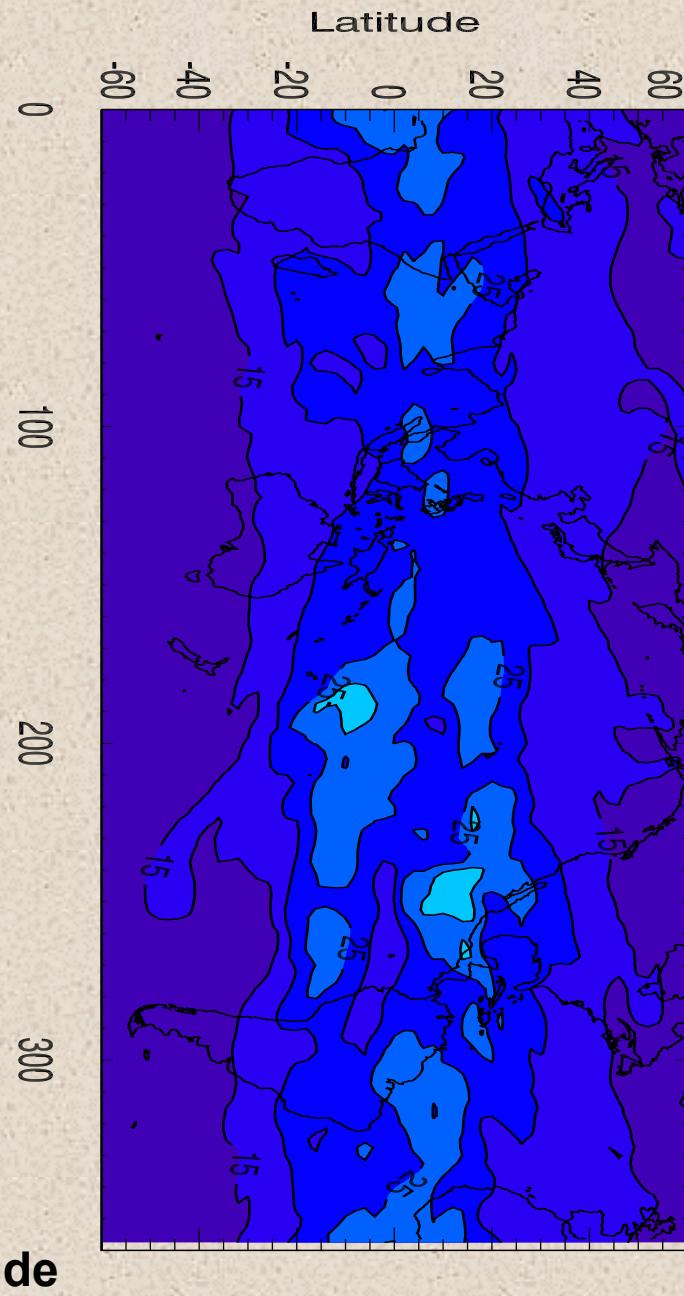
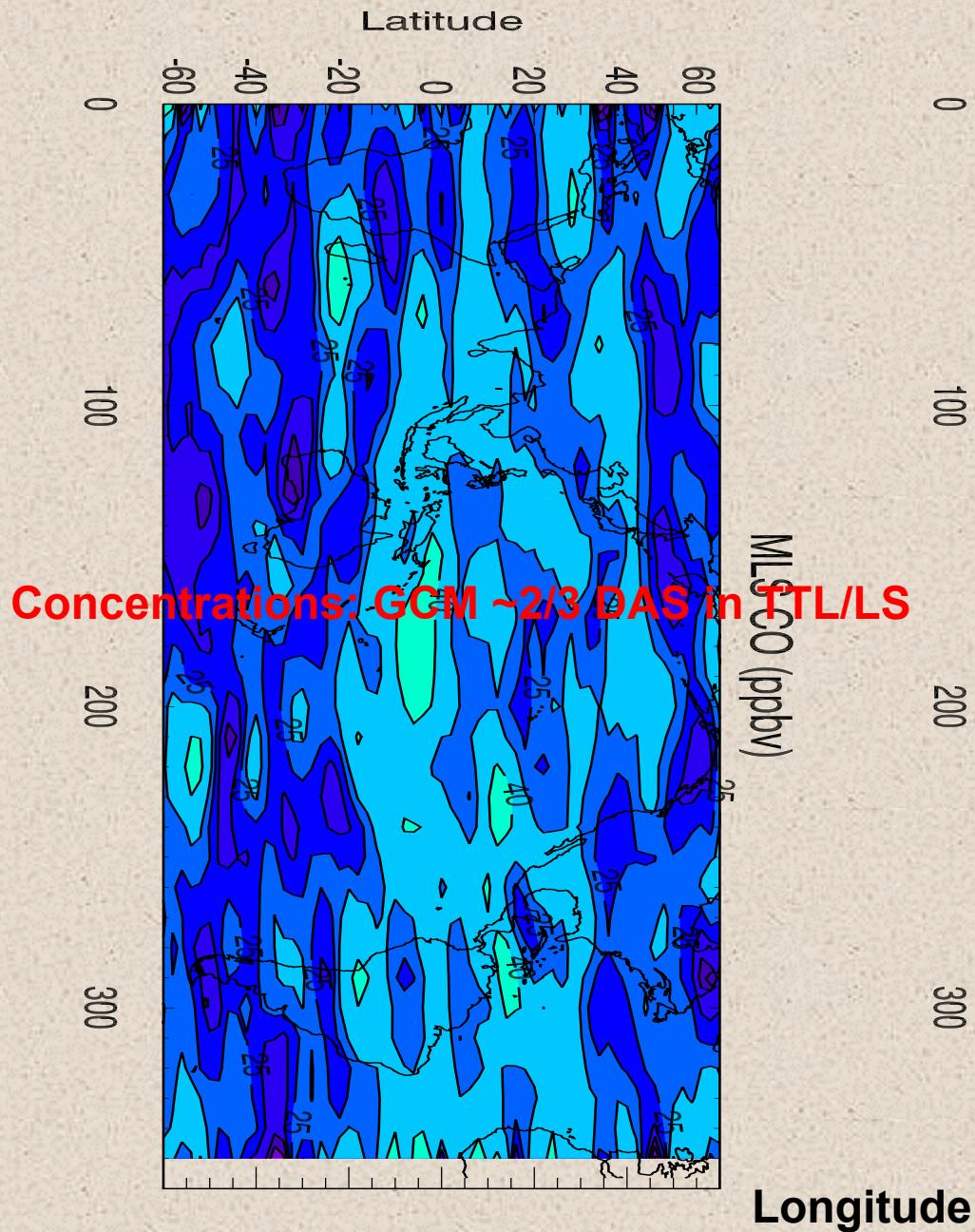
Algorithms for lightning emissions

[Price and Rind, 1992; Pickering et al., 2001]

# *100 hPa : September 21, 2005*



# 68 hPa : September 21, 2005



# *CO Tape Recorder Driven by Seasonal Biomass Burning*

- ⇒ Fires set to clear agricultural fields/pastures before seasonal rains.
- ⇒ Seasonal convection loft pollution to the upper troposphere.

